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Burris, II et al.

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[54] **HIGH PRESSURE GAUGE CARRIER**

[75] Inventors: **Wesley J. Burris, II; Vincent P. Zeller; Jon B. Christensen,** all of Duncan; **William H. Shoffner,** Ryan, all of Okla.

[73] Assignee: **Halliburton Company,** Duncan, Okla.

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[51] **Int. Cl.**⁴ **E21B 41/00;** E21B 47/06

[52] **U.S. Cl.** **166/242;** 73/431; 175/40; 166/64

[58] **Field of Search** 166/264, 64, 162, 163, 166/242, 243; 73/431, 151, 430; 175/40, 50, 320

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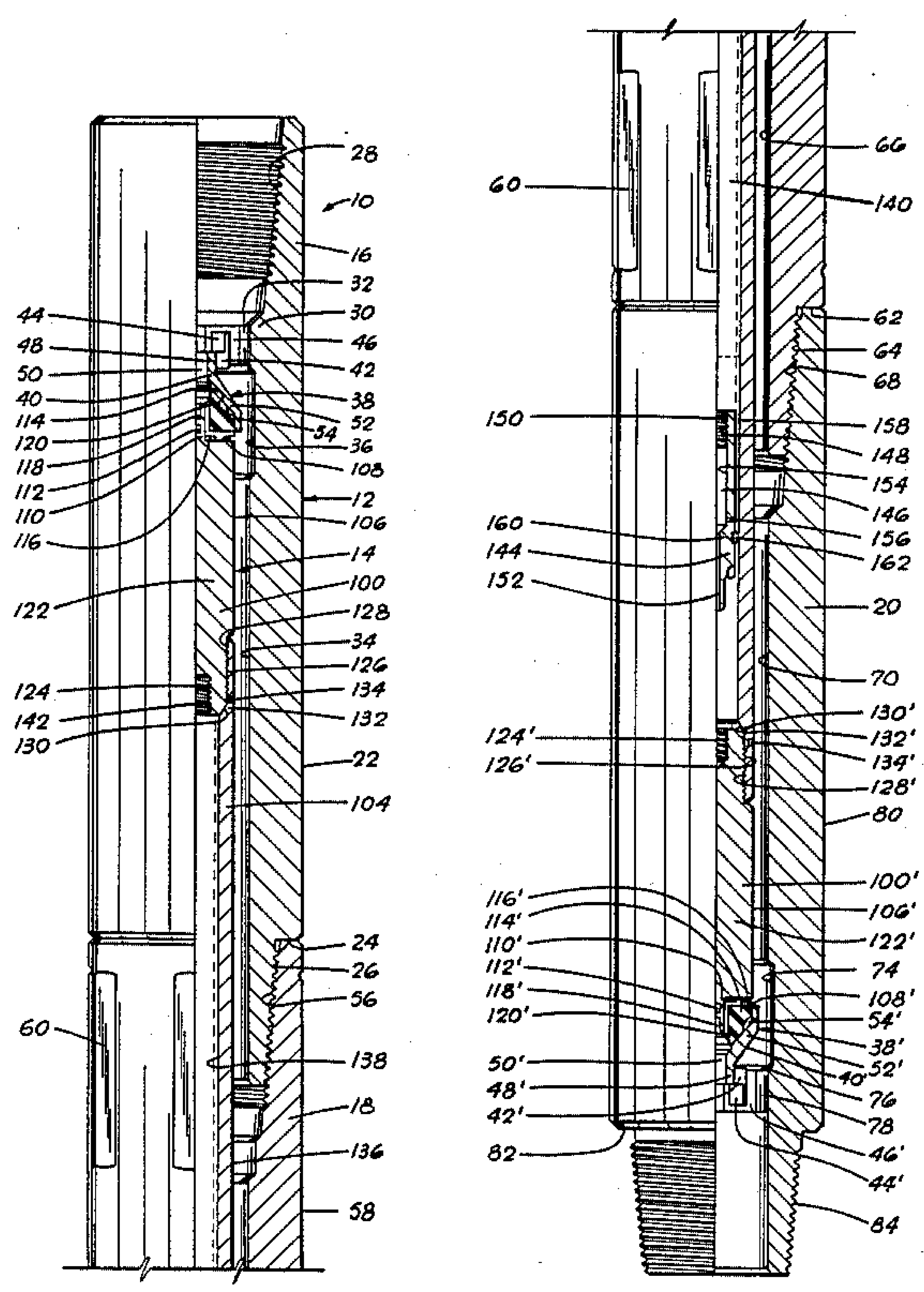
Primary Examiner—Stephen J. Novosad

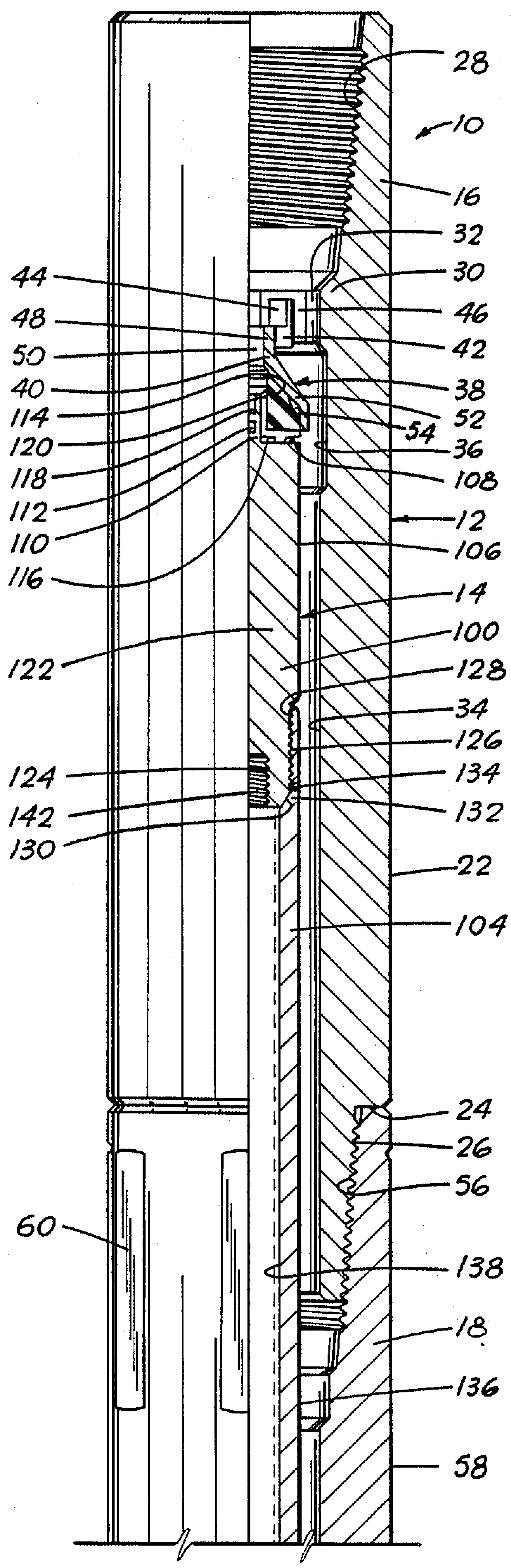
Attorney, Agent, or Firm—James R. Duzan; Joseph A. Walkowski

[57] **ABSTRACT**

The high pressure gauge carrier of the present invention uses an outer gauge carrier housing having disposed therein a pressure-tight inner housing carrying a temperature gauge in the interior thereof. The inner housing is substantially filled with a compressible liquid, and the pressure tight connections of the inner housing incorporated metal to metal seals in order to eliminate the failure of elastomeric seals at the elevated temperatures encountered by the gauge carrier.

10 Claims, 1 Drawing Sheet

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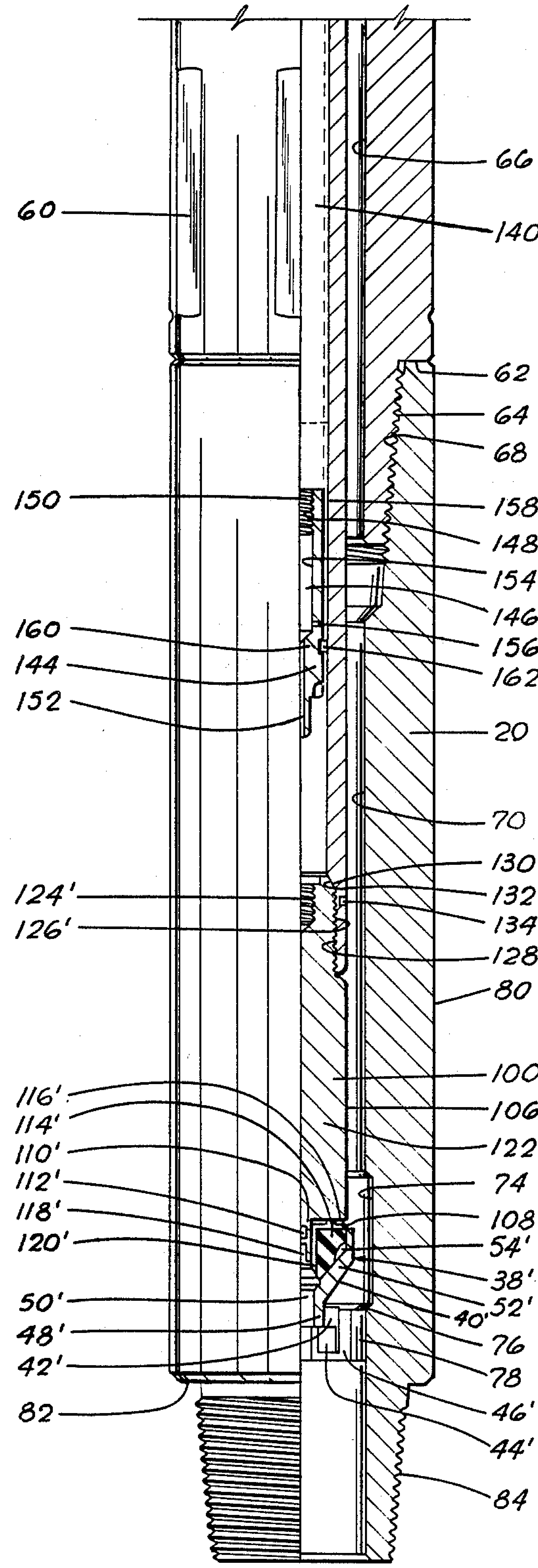
136
58

FIG-1A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132'
124'
134'
126'
128'
80
100'
116'
106'
114'
122'
110'
74
112'
108'
118'
54'
120'
38'
50'
52'
40'
48'
76
42'
78
82
46'
44'
84

FIG-1B

HIGH PRESSURE GAUGE CARRIER

BACKGROUND OF THE INVENTION

It is common practice in the oil and gas industry to conduct temperature measurements during the drilling of a well to acquire data relating to both the bottom hole static temperature and the bottom hole circulating temperature of the well to properly plan and ensure the successful completion of a subsequent cementing operation wherein a tubular conduit, generally referred to as "casing," is cemented into the well bore. As temperature is a critical factor in the type of cement and additives employed in a particular operation, as well as in the setting time of the cement, such data is extremely important to the well operator.

There are two ways in which this temperature data is normally acquired. First, a mechanical or electronic temperature gauge may be incorporated into the bottom of the string of drill pipe through use of a gauge carrier. The second alternative is to deploy a wireline having a temperature transducer at the bottom thereof into the well bore. As oil wells are cemented deeper, however, the hydrostatic pressures encountered at the bottom of these deep wells exceed the limits of available temperature gauges and wireline equipment. As a result, bottom hole circulating and bottom hole static temperature data acquisition efforts needed to complete a successful cement job quite often end with the failure of the temperature gauge or wireline equipment employed, with a resulting lack of necessary data. Thus it became apparent to the inventors of the invention disclosed and claimed herein that a solution to this dilemma must be found.

SUMMARY OF THE INVENTION

The high pressure gauge carrier of the present invention uses an outer gauge carrier housing having disposed therein a pressure-tight inner housing carrying a temperature gauge in the interior thereof. The inner housing is substantially filled with a compressible liquid, and the pressure tight connections of the inner housing incorporate metal to metal seals in order to eliminate the failure of elastomeric seals at the elevated temperatures encountered by the gauge carrier. The compressible liquid inside the inner housing with the temperature gauge serves two purposes. First, the liquid functions effectively as a medium to transmit heat from the well fluid surrounding the inner housing to the temperature gauge therein. Second, by filling the inner housing with a compressible liquid the differential pressure between the exterior of the inner housing and the interior thereof and the temperature gauge is significantly reduced, as the compressible liquid expands and pressurizes the inner case due to the increase in temperature as the gauge carrier on the pipe string goes deeper into the well bore.

BRIEF DESCRIPTION OF THE DRAWINGS

The high pressure gauge carrier of the present invention will be more fully understood by a review of the following detailed description of the preferred embodiment, taken in conjunction with the accompanying drawing, wherein:

FIGS. 1A and 1B of the drawing depict a quarter section vertical elevation of the preferred embodiment of the high temperature gauge carrier of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIGS. 1A and 1B of the drawings, the high pressure gauge carrier **10** of the present invention comprises a substantially tubular outer housing **12** in which is substantially concentrically disposed a second, inner housing **14**.

Outer housing **12** includes three major components: an upper case **16**, a spacer **18**, and a lower case **20**. Upper case **16** includes a generally cylindrical exterior surface **22**, which terminates at its lower end at radially inwardly extending annular shoulder **24**, leading to trailing external threads **26**. The interior of upper case **16** includes threaded entry bore **28** by which gauge carrier **10** may be suspended from a string of drill pipe thereabove. Below entry bore **28**, annular support shoulder **30** extends radially inwardly to cylindrical spider support wall **32**. Below shoulder **30** lies cylindrical bore **34** having annular recess **36** at the upper end thereof.

Upper support spider **38** is disposed adjacent shoulder **30** and recess **36** on the interior of upper case **16**. Support spider **38** includes a central body **40** having a plurality of legs **42** extending radially outwardly therefrom to wall **32**, whereat longitudinally extending feet **44** contact wall **32** and are secured thereto by welds **46**. Legs **42**, of which there are preferably three, are substantially equally spaced at 120° angles from body **40**, defining apertures therebetween to permit well fluid to pass between outer housing **12** and inner housing **14**. Body **40** includes an upper central collar **48** having a central bore **50** extending therethrough, below which downwardly and outwardly extending cone shaped bumper support **52** defines a frustoconical recess **54** having an open lower end.

Tubular spacer **18** is secured to the lower end of upper case **16** via threaded entry bore **56** which engages external threads **26** at the lower end of case **16**, spacer **18** abutting shoulder **24** on upper case **16**. The exterior of spacer **18** is defined by substantially cylindrical surface **58** having flats **60** thereon, the latter of which help in the making up of spacer **18** to upper case **16** and lower case **20**. At the bottom of cylindrical surface **58**, inwardly extending annular shoulder **62** leads to trailing external threads **64**. The interior of spacer **18** below threaded entry bore **56** is defined in major part by cylindrical spacer bore wall **66**.

Lower case **20** is secured to spacer **18** through the engagement of threaded entry bore **68** at the top of case **20** with threads **64** at the lower end of spacer **18**, lower case **20** abutting shoulder **62** on spacer **18**. Cylindrical bore **70** having recess **74** at the lower end thereof lies below threaded entry bore **68**, which terminates adjacent inwardly extending chamfered surface **76** leading to cylindrical lower spider support surface **78**, the latter of which extends to the bottom of carrier **10**, defining an exit bore therefor.

The lower support spider **38'**, although facing upwardly rather than in a downward direction, is in all other respects substantially identical to upper support spider **38**, and therefore identical reference numerals have been employed with respect thereto. Downwardly extending feet **44'** on lower support spider **38'** are, of course, welded via welds **46'** to lower spider support surface **78** in this instance.

The exterior of lower case **20** is defined at its upper extent by substantially cylindrical outer surface **80**, leading to inwardly extending radially oriented annular shoulder **82**, below which external threads extend to the bottom of gauge carrier **10**, by which it can be made up to a string of drill pipe therebelow.

Inner housing **14**, disposed substantially concentrically within outer housing **12**, is also substantially tubular in form. Inner housing **14** comprises, in major part, an upper high pressure plug **100**, a lower high pressure plug **100'**, and a tubular gauge case **104** extending longitudinally therebetween and secured to both, case **104** defining a chamber for receiving a gauge therein. Upper plug **100** has a substantially cylindrical exterior surface **106** having wrench flats thereon. Above cylindrical surface **106** lies radially flat annular bumper shoulder **108**, surrounding upwardly extending cylindrical nose **110** having axial blind bore **112** drilled therein.

A conical bumper assembly **114** including an elastomeric bumper element and having a central axial bore extending therethrough is disposed about nose **110** at the top of upper plug **100**, and rests on shoulder **108**. Metallic collar **116** having a radially extending flange at the bottom thereof extends upwardly into the bore of the bumper element and is bonded thereto. Retaining screw **118** is threaded into blind bore **112** at the top of upper plug **100**, thereby securing bumper retention washer **120** thereto, washer **120** extending outwardly over the top of collar **116** and thereby maintaining bumper assembly **114** on nose **110** of upper plug **100**. The major central portion **122** of upper plug **100** is solid, and is pierced only at its lower end by upwardly extending threaded blind gauge bore **124**. The lower exterior of upper plug **100** includes threaded surface **126** thereon, by which gauge case **104** is secured thereto by internal threads **128**. The trailing edge **130** of upper plug **100** is polished and of a frustoconical configuration, and cooperates with polished frustoconical seal bore **132** on the interior of gauge cas **104** below internal threads **128** to form a pressure-tight metal to metal seal. At least one vent port **134**, which extends through the wall of gauge case **104** interposed between threaded bore **128** and seal surface **132**, ensures that upper plug **100** can be easily made up to gauge case **104**, and that no pressure will be trapped between the threaded connection therebetween and the metal to metal seal effected by the cooperation of trailing edge **130** and seal bore **132**. The exterior of gauge case **104** comprises a generally cylindrical surface **136**, surface **136** having wrench flats at the top and bottom thereof to facilitate securing of gauge case **104** to upper plug **100** and lower plug **100'**. The interior of gauge case **104** is also substantially cylindrical throughout its major portion, being defined by bore wall **138**. The lower end of gauge case **104** is substantially identical to the upper end thereof, possessing an internally threaded bore **128'** and a lower seal bore **132'**, with at least one radial port **134'** extending through the wall of gauge case **104** interposed therebetween.

Lower plug **100'** is substantially identical to upper plug **100**, except its orientation as a part of inner housing **14** is reversed 180° from that of upper plug **100**. A metal to metal seal is effected between the lower end of gauge case **104** and the upper end of lower plug **100'** by cooperating seal bore **132'** and edge **130'**. Likewise, lower bumper assembly **114'**, including an elastomeric element and a metal collar **116'**, is substantially identical to upper bumper assembly **114** with associated collar **116**. Lower bumper assembly **114'** is likewise secured to lower plug **100'** via a retainer screw **118'** and washer **120'**, these being substantially identical to screw **118** and washer **120** associated with upper plug **100'**.

Inside inner housing **14**, a temperature gauge such as (by way of example and not limitation) the BT or RT-7 temperature recorders, employed by Halliburton Services and described in Halliburton Services Sales and Service Catalog No. 43 at page 2535, is depicted in phantom by broken lines and identified by reference numeral **140** and the broken lead line associated therewith. Gauge **140** is secured in inner case **14** via threaded nose **142** at the top thereof, which engages threaded gauge bore **124** of upper plug **100**. Of course, other well known connection means may be employed, such as lugs or keys.

The lower end of temperature gauge **140** is preferably secured to extension **144** having bore **146** extending therethrough, the upper end of which **148** is threaded and engages an externally threaded tail **150** on gauge **140**. The lower portion **152** of bore **156** is substantially smaller than the upper portion **154** thereof, and immediately adjacent the juncture of the two bore portions, a plurality of radial ports **156** extend outwardly through the wall of extension **144** between bore **146** and the exterior surface **158** thereof. Exterior **158** includes an annular groove **160** therein slightly below ports **156**, in which a seal ring **162**, preferably of filled Teflon, is disposed to act in centralizing the lower end of gauge **140** in housing **14**, and to assist in cushioning gauge **140** against lateral shocks.

When it is desired to use temperature gauge **140** to measure the bottom hole static or circulating temperature in a deep, hot well of the previously mentioned type which may cause conventional equipment to fail, gauge **140** is prepared according to conventional procedure, the timer therein is set and started, and gauge **140**, with extension **144** secured to the lower end thereof, is lowered into inner housing **14** by upper plug **100**, to which gauge **140** is secured at its top. The interior of inner housing **14** will have been previously partially filled with a compressible liquid such as silicone oil. As gauge **140** with extension **144** attached thereto is lowered into gauge case **104** of inner housing **14**, silicone oil therebelow is displaced through the lower portion **152** of extension bore **146** to the exterior of extension **144** above seal **162**, bypassing the latter and filling housing **14** about the exterior of gauge **140**. Excess silicone oil is placed in inner housing **14**, so that when temperature gauge **140** is fully inserted therein, and upper plug **100** by which gauge **140** is lowered into gauge case **104** is threaded to the top of gauge case **104**, excess oil will be displaced through ports **126** at the top of gauge case **104**, a metal to metal seal being effected between upper plug **100** and gauge case **104** via trailing edge **130** and seal bore **132** immediately therebelow. In such a manner, it is ensured that substantially all of the air in inner housing **14** has been removed. In some instances where the gauge carrier **10** is to be deployed in an extremely hot or deep well, a slight amount of air may be intentionally left inside inner housing **14**. This air will compress to a negligible volume before the compressible liquid begins to exert significant pressure on the inside of inner housing **14** due to temperature induced expansion, thus preventing that pressure from acting on inner housing **14** before there is sufficient hydrostatic pressure outside of housing **14** to balance the inside pressure and prevent inner housing **14** from bulging or otherwise distorting.

Inner housing **14**, with temperature gauge **140** secured therein, is then lowered into outer housing **12** with upper case **16** removed therefrom, until lower bumper assembly **114** rests on lower support spider **38'**. Upper case **16** is then lowered over the upwardly extending top of inner housing **14** protruding above spacer **18**, and is made up thereto so that inner housing **14** is held between upper support spider **38** and lower support spider **38'** of outer housing **12**, bumper assemblies **114** and **114'** acting as shock absorbers between the inner and outer housings. Collars **116** and **116'** permit relatively free rotation during the making up of upper case **16** and the previously assembled spacer **18** and lower case **20** without the risk of partially backing off the threaded connections in inner housing **14**, and the breaking of the metal to metal seals associated therewith.

Fully assembled gauge carrier **10** is then included in a string of drill pipe, and is gradually lowered to the bottom of the well bore as stands of pipe are added thereabove. Gauge carrier **10** with gauge **140** therein is subsequently retrieved from the well, and the data acquired by gauge **140** is employed in planning the subsequent cementing operation. While in the well bore, well fluids can be freely circulated between outer housing **12** and inner housing **14** due to the use of upper and lower support spiders **38** and **38'** respectively, which provide passage for the well fluids about inner housing **14** and between the exterior thereof and the inner wall of outer housing **12**.

While disposed in the well bore, temperature gauge **140** is protected from pressure by inner housing **14** with its upper and lower metal to metal seals between case **104** and upper and lower plugs **100** and **100'**, respectively. Gauge **140** is centralized inside inner housing **14** by extension **144** and its associated seal **162**, the latter of which, as previously mentioned, also acts as a cushion against lateral shock. Moreover, the filling of inner housing **14** with a compressible liquid and the expulsion of air therefrom befor closing of housing **14** provides support for the inner housing **14** from within, as the compressible liquid increases (slightly) in volume and, therefore, pressure as the temperature of carrier **10** increases as it travels deeper in the well bore. This pressure increase lessens the differential pressure between the inside and the outside of case **14**, relieving some stress thereon by the hydrostatic pressure of the fluids in the well bore. Furthermore, the liquid acts as a damper to vibration of gauge **140** inside housing **14**. Finally, the presence of the compressible liquid acts as an efficient medium for the transfer of heat from the exterior of inner housing **14** to the interior thereof and so to the transducer incorporated in temperature gauge **140** by which the temperature of the well bore, both in a static and a circulating mode, may be measured. Upper and lower bumper assemblies **114** and **114'**, respectively, act as cushions against longitudinal shock to gauge **140** through housing **14**, and also act as bearings permitting the making up of outer housing **12** without the backing off of any of the threaded connections between the components of inner housing **14**.

Thus it is apparent that a novel and unobvious high pressure gauge carrier has been invented. While the present invention has been described in terms of a preferred embodiment, it will be apparent to those of ordinary skill in the art that the invention is not so limited. For example, the use of cooperating inner and outer housings could be employed in a gauge carrier of different configuration, such as a bundle carrier in which a plurality of inner housings containing gauges are disposed about or adjacent to a central or offset bore running through the outer housing of the carrier; the shock absorbing mechanism could be changed; more than one gauge might be placed in an inner housing; the bumper assemblies could be incorporated in the outer housing; and others. Such modifications and other additions, deletions and modifications to the invention as described in the preferred embodiment may be made without departing from the spirit and scope of the claimed invention.

We claim:

1. A gauge carrier for disposition in a well bore, said gauge carrier comprising:

an inner pressure-tight housing having a chamber therein adapted to receive at least one gauge;

an outer housing including support means for said inner housing therein; and

a compressible liquid substantially filling any space in said chamber unfilled by said gauge.

2. The apparatus of claim **1**, wherein said inner housing has an openable end connection, said connection including a metal to metal pressure seal.

3. A high pressure gauge carrier for running a gauge into a well bore, said high pressure gauge carrier comprising:

an outer housing;

longitudinally spaced upper and lower support means in said outer housing adapted to engage and support a tubular inner housing;

a tubular inner housing having a pressure-tight chamber therein for receiving said gauge, said inner tubular housing having bumper means at the upper and lower ends thereof for engagement by said support means of said outer housing; and

compressible liquid, such as compressible silicone oil, filling any voids in said tubular inner housing and between said tubular inner housing and said outer housing.

4. A high pressure gauge carrier for running at least one gauge into a well bore, said high pressure gauge carrier comprising;

an outer housing;

longitudinally spaced upper and lower support means in said outer housing adapted to engage and support tubular inner housing; and

a tubular inner housing having a pressure-tight chamber therein for receiving said at least one gauge, said inner housing having bumper means at the upper and lower ends thereof for engagement by said support means of said outer housing, said tubular inner housing including:

a tubular case defining said chamber and having at least one open end;

at least one end plug adapted to close off said at least one open end and

cooperating metal sealing surfaces at said at least one open end and said at least one end plug,

wherein said at least one gauge is secured at one end to said at least one end plug, the other end of said at least one gauge being secured to an extension means adapted to be received inside said tubular case chamber and including centralizing means disposed thereabout and adapted to extend between said extension means and the interior of said tubular case.

5. The apparatus of claim 4, wherein said at least one gauge is threaded to one end of said extension means, said extension means includes an axial bore therethrough, and further includes port means located between said gauge and said centralizing means and extending through the wall of said extension means between the axial bore and the exterior thereof.

6. A high pressure gauge carrier for running a gauge into a well bore, said gauge carrier comprising:

a tubular outer housing;

longitudinally spaced upper and lower support means in said outer housing adapted to engage and support an inner housing, said upper and lower support means of said outer housing each comprising a support spider, each said spider including, in turn, a central collar having laterally oriented circumferentially spaced legs extending therefrom and secured to the interior of said outer housing, said collar including, in turn, bumper engagement means thereon; and

a tubular inner housing having a pressure-tight chamber therein for receiving said gauge, said inner housing having bumper means at the upper and lower ends thereof for engagement by said support means of said outer housing

wherein said bumper engagement means comprise frustoconical recesses, and said bumper means comprise bumper assemblies including elastomeric bumpers thereon receivable in said recesses, said bumper assemblies being rotatably secured on the upper and lower ends of said inner housing, whereby said inner housing extends longitudinally between said support means in said outer housing.

7. The apparatus of claim 6, wherein said inner housing is substantially concentrically disposed in said outer housing.

8. The apparatus of claim 7, wherein said inner housing includes:

a tubular case defining said chamber and having at least one open end;

at least one end plug adapted to close off said at least one open end; and

cooperating metal sealing surfaces at said at least one open end and on said at least one end plug.

9. The apparatus of claim 8, wherein said at least one gauge is secured at one end to said at least one end plug, the other end of said at least one gauge being secured to an extension means adapted to be received inside said tubular case chamber and including centralizing means disposed thereabout and adapted to extend between said extension means and the interior of said tubular case.

10. The apparatus of claim 9, wherein said at least one gauge is threaded to one end of said extension means, said extension means includes an axial bore therethrough, and further includes port means located between said gauge and said centralizing means and extending through the wall of said extension means between the axial bore and the exterior thereof.

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